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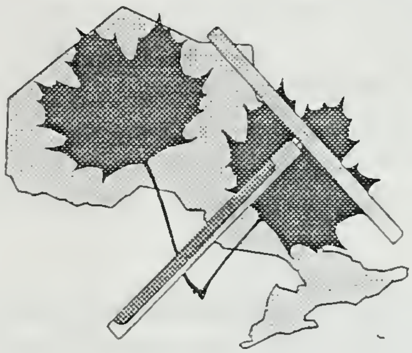
PHYTOTOXICOLOGY TECHNICAL MEMORANDUM



Phytotoxicology 1998 Investigation:

The Village of Deloro, Ontario

Phytotoxicology Investigator:
Murray Dixon

Report No. SDB-056-3511-1998

Phytotoxicology and Soil Standards Section, Standards Development Branch
Ontario Ministry of the Environment
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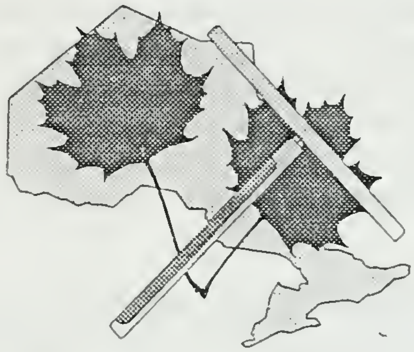

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I. Introduction

The village of Deloro is located in Hastings County, south central Ontario, adjacent to the abandoned Deloro gold mine and ore processing site (Deloro Mine Site). As a result of a century of mining, smelting, refining, and pesticide production, the mine site is highly contaminated with numerous chemicals and radioactive material. In order to determine the extent of contamination both on the Deloro Mine Site and surrounding area, the Phytotoxicology and Soil Standards Section of the Ontario Ministry of the Environment (MOE) conducted a study in 1986 and 1987 (MOE,1998) that involved the sampling of soil and native vegetation within 1.5 km of the mine site, moss bag monitoring of aerial deposition, sampling of garden vegetables in the village of Deloro and soil toxicity testing through laboratory bioassays. The results of the soil sampling found the Deloro Mine Site to be significantly contaminated (exceeding provincial soil clean-up guidelines) with arsenic and cobalt as well as copper, nickel, and silver. Limited sampling in the village of Deloro found the soil to be significantly contaminated with arsenic and cobalt and marginally contaminated (above the upper limit of background concentrations) with lead, nickel, and silver. The mine site was identified as the source of this contamination. The moss bag study in 1986 indicated that blowing dust was not causing significant contamination in areas adjacent to the mine site. Garden produce sampling indicated that the concentrations of arsenic in edible vegetable produce did not exceed the former federal government arsenic food guideline. The results of the bioassay found that nickel, copper, and cobalt were the contaminants most readily taken up from the Deloro soils and that bean growth was reduced in highly contaminated soil from Deloro. Arsenic concentrations in plants were consistently elevated where soil levels were also high.

In 1998, a MOE health risk assessment was initiated in response to ongoing concern that contamination from the Deloro Mine Site may be adversely affecting the health of residents of the village of Deloro and surrounding area. As part of this study, the Phytotoxicology and Soil Standards Section was asked to determine the extent of contamination in the village of Deloro through sampling of surface soil from all residential properties in the village and several adjacent residences. In addition, four vegetable species were grown in Deloro gardens in order to determine the extent of contaminant uptake into the garden produce.

II. Methods

On April 22, 23 and 24, 1998, surface soil samples (0-5 cm) were collected from the front and back yards of all residential properties in the village of Deloro, as well as from 6 properties north of the Deloro Dam Road and 2 properties west of the village. In order to obtain representative soil samples, small plugs of soil, each 2.0 cm in diameter and 5 cm long, were collected with a stainless steel soil corer (Oldfield ®) in an X or Z pattern across each yard. One composite sample consisted of at least 20 plugs, which were placed in a polyethylene bag. This process was repeated in order to obtain duplicate samples from each yard. The soil samples were sent to the MOE Laboratory Services Branch for analysis. The soils were air dried for a minimum of 48 hours, homogenized and sieved first through a 2 mm sieve and then ground and sieved through a 355 μm sieve. The resulting samples were analysed for aluminum, barium, beryllium, calcium,

cadmium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, strontium, vanadium, and zinc using the MOE Laboratory Services method E3073. Arsenic, silver, and uranium were analysed using the MOE Laboratory Services methods E3245A, E3075A and E3215A respectively. In addition, subsamples of each soil were sent to the Ontario Ministry of Labour for radionuclide analysis. These samples were dried, ground and sealed for 30 days and then counted for 10,000 seconds each by gamma spectrometry. These data are reported on a "as received" basis.

On 27 May, 1998, garden soil samples (0 - 15 cm) were collected from 7 gardens in the village of Deloro and surrounding area These soils were analysed for the same elements and in the same way as the residential surface soils. Vegetables (beans, beets, carrots, and lettuce) were planted from seed in these gardens on 27 May, 1998 and harvested on 29 July, 1998. Control vegetables were planted from seed in a field plot at the Phytotoxicology laboratory on 29 May, 1998 and harvested at the same time as the Deloro vegetables. Harvested vegetables were washed with tap water, as if for consumption, chopped and dried at 80°C for at least 48 hours and then ground in a mill (Wiley mill ®) to pass through a 1 mm screen. The ground samples were analysed for barium, beryllium, boron, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, strontium, vanadium, and zinc using the MOE Laboratory Services method E3065A. Arsenic and selenium were analysed using the MOE Laboratory Services method E3245A, and uranium was analysed using method E3214A.

Analysis of variance was performed using the statistical software package Systat® (SPSS Inc., 1996). Concentration contour maps were created using the software package Surfer® (Golden Software, Inc., 1996). The data was gridded using the Kriging method, using the linear varigram model, with the all data search type and grid lines set at x= 76 and y= 100.

III. Results and Discussion

Figure 1 shows the location of the village of Deloro relative to the Deloro Mine Site.

Residential surface soil samples

The analytical results from the residential surface soil sampling were divided into two tables (Appendix 1 and 2), on the basis of contaminant concentrations relative to Ontario soil clean-up guidelines (Appendix 3) which are effects-based guidelines, and to background concentrations Table F (MOE, 1997) or OTR98 values (Appendix 4). The use of two sets of background values (Table F and OTR98) can be confusing. The OTR_{98} represents the 97.5 percentile of the chemical concentration in soils sampled from old urban parkland throughout Ontario. Table F values are OTR98 values plus two coefficients of variation. Table F values take into consideration within-site sampling variability, which means that if a chemical concentration in a single sample is above the Table F value, one can be certain (97% confidence) that the OTR98 has been exceeded for that chemical (MOE, 1996). Table F values were developed to minimize costly replicate sampling, primarily for organic contaminants (MOE, 1996). Since the data presented in Appendices 1 and 2 as well as in the figures in this report are the results of inorganic analysis of

duplicate soil samples where there was little variability within a station, the extra buffer of certainty was considered unnecessary and comparisons to background concentrations are generally made to the OTR98 values. Appendix 1 includes the contaminants that pose the greatest environmental concern in Deloro, whereas Appendix 2 includes elements that pose little environmental concern or that are at or below analytical detection limits. In these appendices, "station" numbers generally refers to either front or back yards. The values in these appendices are average values of duplicate surface soil samples, which generally had little variability. The elements of greatest concern were arsenic, cobalt, lead, nickel, and silver. Summary statistics for these elements as well as barium, copper, strontium, uranium, and zinc are included in the main body of this report (Table 1).

In Appendices 1 and 2, effects based guideline values, commonly referred to as "Table A" values (MOE, 1996), are given for comparison with sampled values. These are Ontario soil clean-up guidelines for residential land use for a potable groundwater condition. The distinction between the two Table A values, denoted Table A (f) and Table A (c), is based on soil texture. Table A (f) is for medium and fine textured soils and Table A (c) is for coarse textured soils. Soil texture, which is a measure of the proportion of sand, silt and clay in a soil, can greatly influence the availability of metals to living organisms. In general, finer textured soils, such as clays, bind contaminants to a greater extent than coarse textured soils, such as sands. The soil survey of Hastings County describes the soil in the village of Deloro as a "Deloro loam" that was developed from red and grey calcareous shale (Gillespie et al., 1962). Field observations confirmed that soils on most properties were loams. In the soil clean-up guidelines, coarse textured soils are considered sands or sandy loams (70% of the particles equal or greater than 50 μm in diameter) and fine textured soils are considered loams and clays. Therefore, Table A (f) values, for medium and fine textured soils, are applicable guideline values for most Deloro properties.

Table 1: The mean, median, minimum and maximum concentrations (μg/g dry weight) of selected metals in surface soil of residential properties in the vicinity of the village of Deloro, April 1998.

	Arsenic	Barium	Cobalt	Copper	Lead	Nickel	Silver	Strontium	Uranium	Zinc
mean	111	163	57	29	121	44	3.7	36	0.376	128
median	78	150	41	24	95	34	2.5	32	0.331	115
minimum	2	46	5	6	4	9	0.0	14	0.159	25
maximum	605	405	340	115	655	195	20.5	103	1.410	430
OTR98†	17	180	17	65	98	32	0.30	78	1.400	140
Table F	17	210	21	85	120	43	0.42	NV	NV	160
Table A (f)	25	1000	50	300	200	200	25.0	NV	NV	800
Table A (c)	20	750	40	225	200	150	20.0	NV	NV	600
Exceedance★	123	0	59	0	25	0	0			0

† 98th percentile of the Ontario Typical Range (see Apendix 3)
Table F - Ontario background concentrations (MOE, 1997)
Table A (f) - Soil remediation criteria for fine textured residential sites in a potable groundwater situation (MOE, 1996)
Table A (c) - Soil remediation criteria for coarse textured residential sites in a potable groundwater situation (MOE, 1996)
★ - the number of stations out of 145 that exceeded the soil clean-up guideline (Table A (f)).
NV - no value

Arsenic concentrations were highly elevated throughout the village of Deloro. The highest arsenic concentration in the village was 605 μg/g, which is approximately 24 times the soil clean-up guideline for fine textured residential soil of 25 μg/g. Of the 145 stations sampled, 123 exceeded this arsenic soil clean-up guideline (Table 1). The median arsenic value of 78 μg/g, with half the station values greater than this value and half the station values less than this value, also exceeded the soil clean-up guidelines. The maximum and minimum arsenic concentrations were both from samples taken in the village of Deloro. While high arsenic values were expected in the village, values less than the upper limit of background concentrations OTR98 were not expected since the area has been historically impacted by arsenic emissions from the Deloro smelter. Values below the OTR98 value are probably due to landscaping done after the smelter closed (eg. clean fill covering contaminated soil).

In order to determine whether the stations adjacent to the old Deloro Mine Site had higher arsenic concentrations than stations farther from the old Deloro Mine Site, arsenic concentrations in soil samples were compared between backyards of properties on the east and west sides of O'Brien Street from the corner of Deloro Road to the south and 51 O'Brien Street to the north. The results of the Analysis of Variance indicated that there was no statistically significant difference ($p= 0.974$) in arsenic concentrations in backyard soils between these two locations. These results are in part due to the large variability in arsenic concentrations among adjacent properties on both sides of O'Brien Street. Nevertheless, they suggest that greater proximity to the mine site, within the village of Deloro, does not necessarily mean higher soil arsenic contamination.

The spacial distribution of arsenic in the village of Deloro is shown in Figure 2. This map provides a general pattern of contamination. However, contamination contour maps can not be used to determine the actual concentration of a contaminant at a location where a sample was not taken, nor will all sampling locations within a contour necessarily have the indicated contaminant concentration. The lowest contour in Figure 2 is set at the lowest soil clean-up guideline value for arsenic of 20 μg/g. Areas above this contour are considered significantly contaminated. In general, most properties lie between the 40 and 100 μg/g arsenic contours. However, two areas in the south end of the village have concentration contours at 200 μg/g. The Deloro Mine Site is the probable source of arsenic contamination in the village of Deloro.

Cobalt concentrations were also very high in the village of Deloro, with a maximum concentration of 340 μg/g and 59 of the 145 stations exceeding the soil clean-up guideline for cobalt in fine textured soils of 50 μg/g (Table 1). The median concentration of cobalt of 45 μg/g was just below the soil clean-up guideline. The spacial distribution of cobalt in the village of Deloro is shown in Figure 3. The lowest contour is set at the lowest soil clean-up guideline value for cobalt of 40 μg/g. Areas above this contour are considered significantly contaminated. The highest cobalt concentrations are in the middle of the village and on the northwest corner of Deloro Road and O'Brien Street. As with arsenic, the source of contamination is probably the Deloro Mine Site.

Lead concentrations at 25 of the 145 stations exceeded the clean-up guideline criteria for lead of

200 $\mu g/g$. The median value for lead of 97 $\mu g/g$ was slightly below the OTR98 value of 98 $\mu g/g$ (Table 1), which suggests that lead contamination was localized. The lead concentration contour map (Figure 4), shows the highest lead concentrations in the middle of the village on the west side of O'Brien Street. For lead, the lowest contour was set at approximately the OTR98 value. Areas above this contour and below the 200 $\mu g/g$ contour are considered marginally contaminated. Areas above the 200 $\mu g/g$ contour are significantly contaminated. The source of the lead contamination is not clear. It may be associated with the historical production of lead arsenate on the Deloro Mine Site, or it may be due to the peeling of lead based paints from houses or it may be associated with the historic use of lead arsenate pesticides. Identification of the source of the localized lead contamination requires further investigation.

Nickel concentrations in the village of Deloro were elevated above normal background concentration but below the soil clean-up guideline for medium and fine textured residential soils. The lowest contour (see Figure 5) was set at approximately the OTR98 value. Areas above this contour are considered marginally contaminated (Table 1). No contours exceeded the nickel soil clean-up guideline value. High nickel concentrations tended to be in the same areas as the high arsenic and cobalt concentrations.

Silver concentrations in the village of Deloro were generally above the OTR98 value but below or just at the soil clean-up guideline. The median concentration of 2.9 $\mu g/g$ is approximately 10 times the OTR98 of 0.3 $\mu g/g$. As with nickel, the lowest contour (see Figure 6) was set at the OTR98 value and not at a soil clean-up guideline (Table 1). No contours exceeded the silver soil clean-up guideline value. The pattern of contamination in the village was similar to that of arsenic, cobalt, and nickel.

The maximum values of barium, copper, strontium, uranium and zinc all exceeded the OTR98 but were below their respective soil clean-up guidelines (Table 1). This level of contamination in the village of Deloro is probably associated with the atmospheric emissions from the various mining and smelting activities that were carried out at the Deloro Mine Site.

In general, the elements listed in Appendix 2 were not considered to be at concentrations of concern. Nevertheless, the concentrations of several elements exceeded their respective OTR98 values. One beryllium value was at the Guideline value of 1.2 $\mu g/g$. However, this elevated beryllium concentration may be because the Deloro soils are derived from shale and shale derived soils commonly have high beryllium concentrations. It should also be noted that this is a <T value, which means there is analytical uncertainty about this value. Other elements that exceeded their respective OTR98 values were cadmium, chromium, and manganese, which, at the concentrations reported, pose little environmental concern. Finally, one calcium value at station 183 was almost twice the OTR98 value. This may simply reflect naturally high calcium concentrations in the Deloro area, since the Deloro soils were developed from calcareous shale (Gillespie et al., 1962). Nevertheless, field notes indicated that this material was probably fill, possibly brought in from another location.

Figure 1: The Deloro Mine Site, Village of Deloro and Surrounding Area

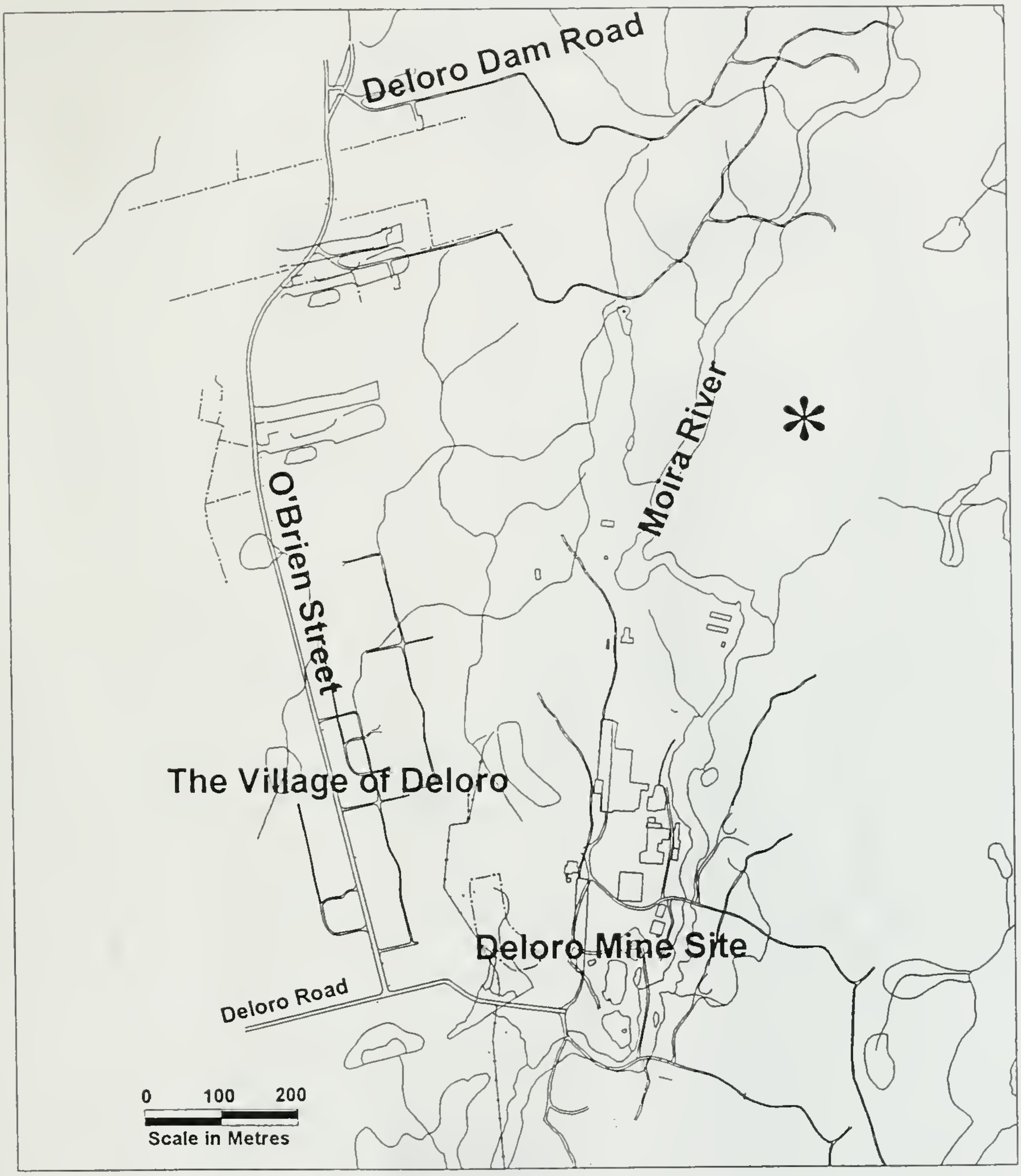


Figure 2: Concentration Contour Map of Arsenic ($\mu g/g$) in Soil Collected in the Vicinity of the Village of Deloro

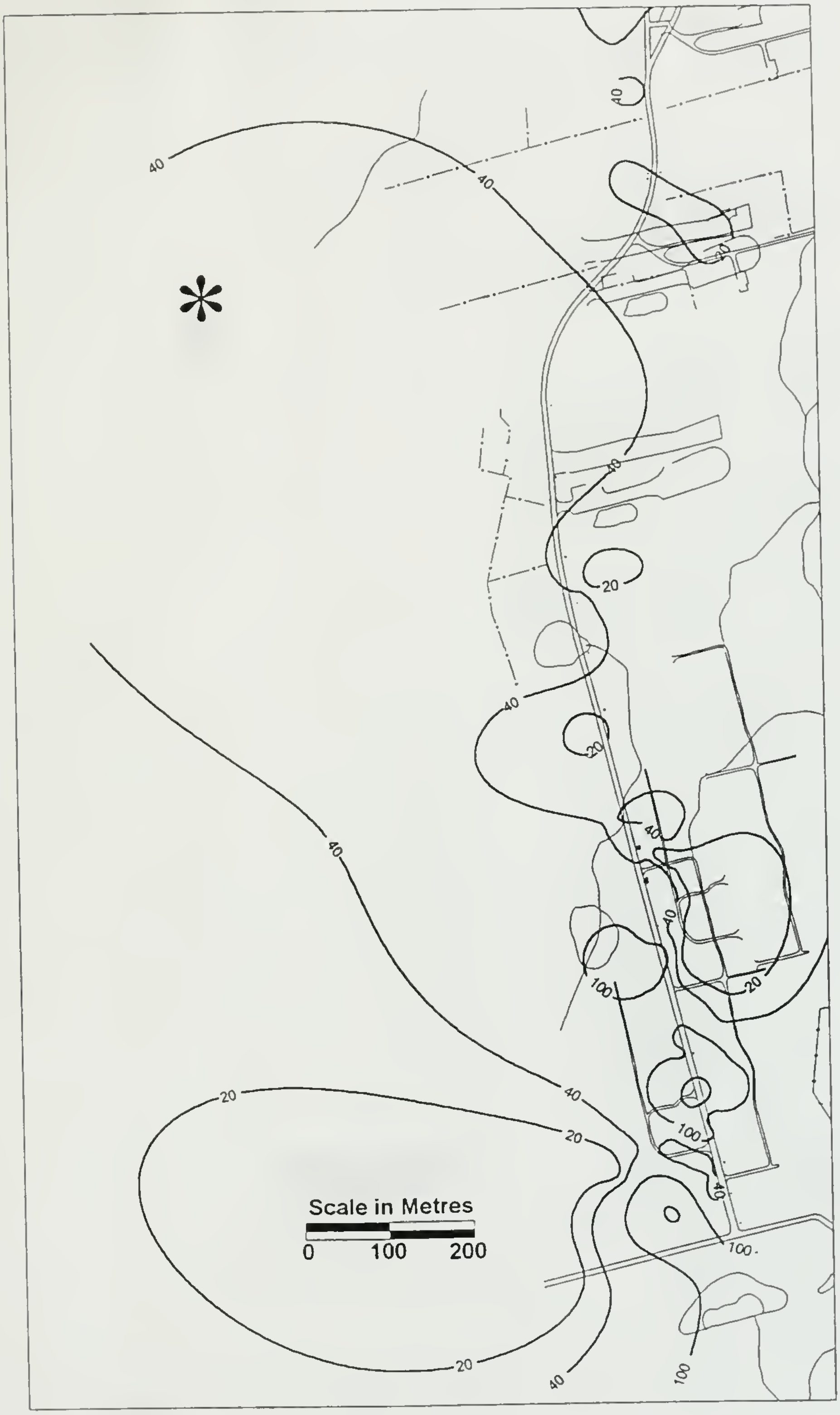


Figure 3: Concentration Contour Map of Cobalt ($\mu g/g$) in Soil Collected in the Vicinity of the Village of Deloro

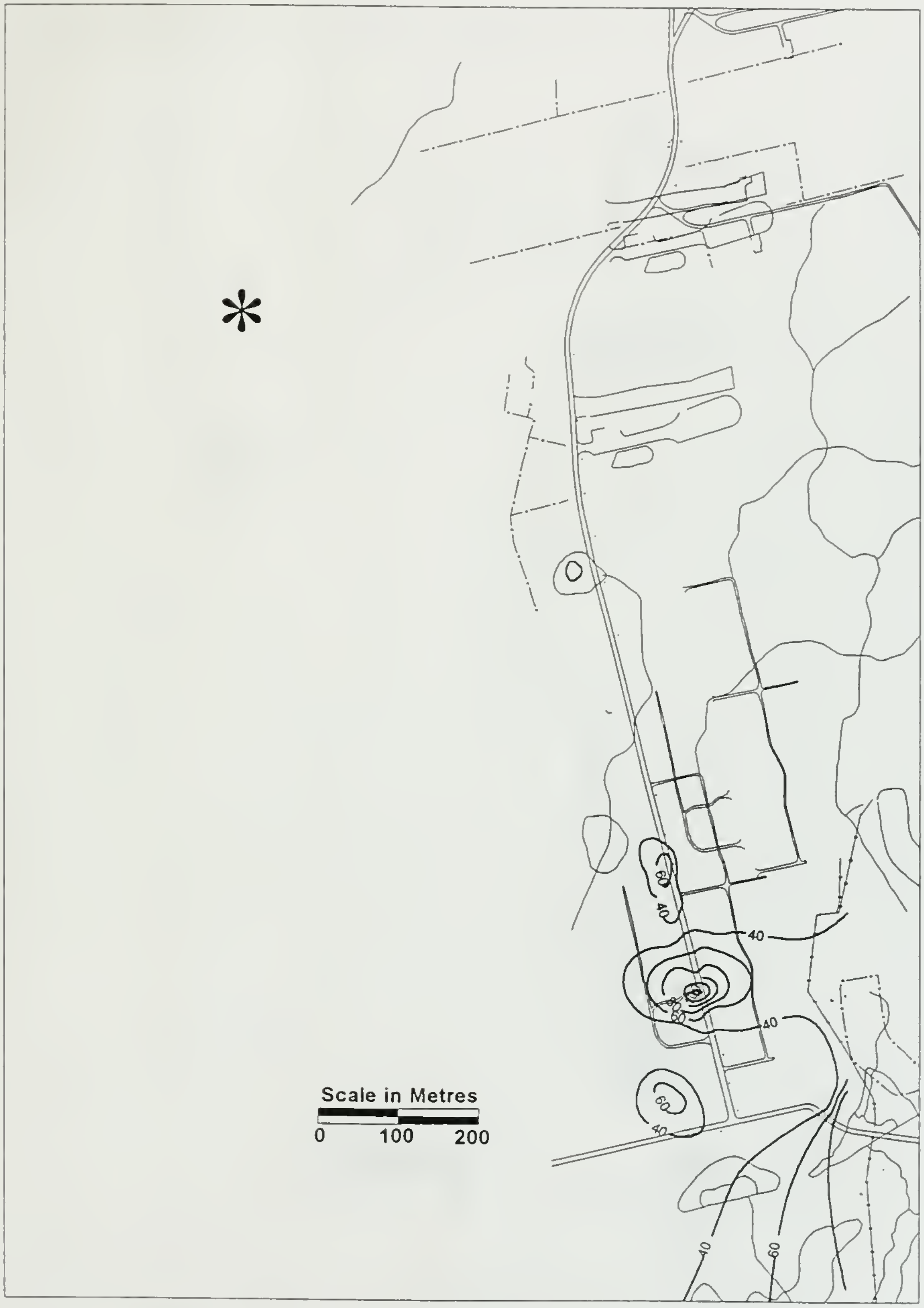


Figure 4: Concentration Contour Map of Lead ($\mu g/g$) in Soil Collected in the Vicinity of the Village of Deloro

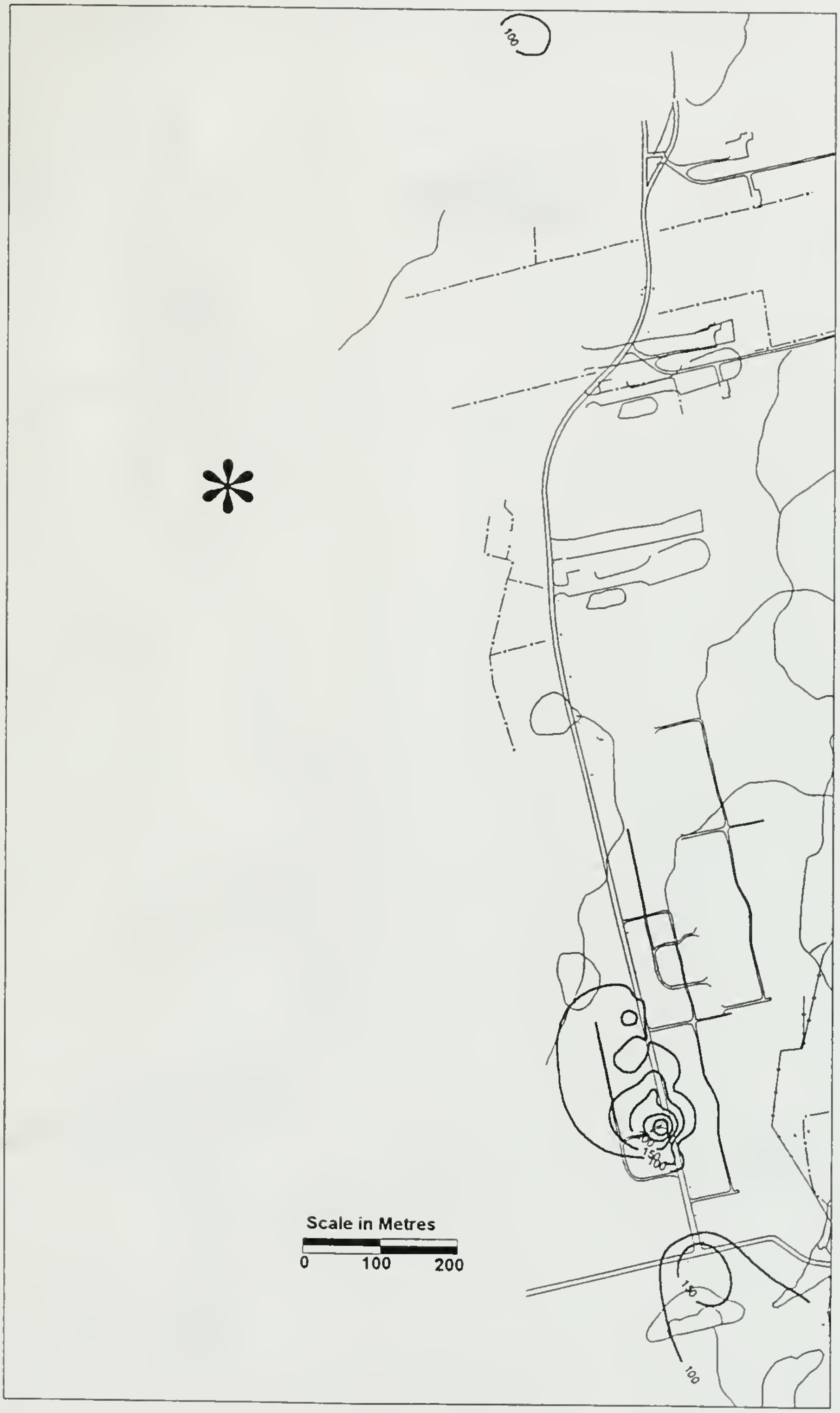


Figure 5: Concentration Contour Map of Nickel ($\mu g/g$) in Soil Collected in the Vicinity of the Village of Deloro

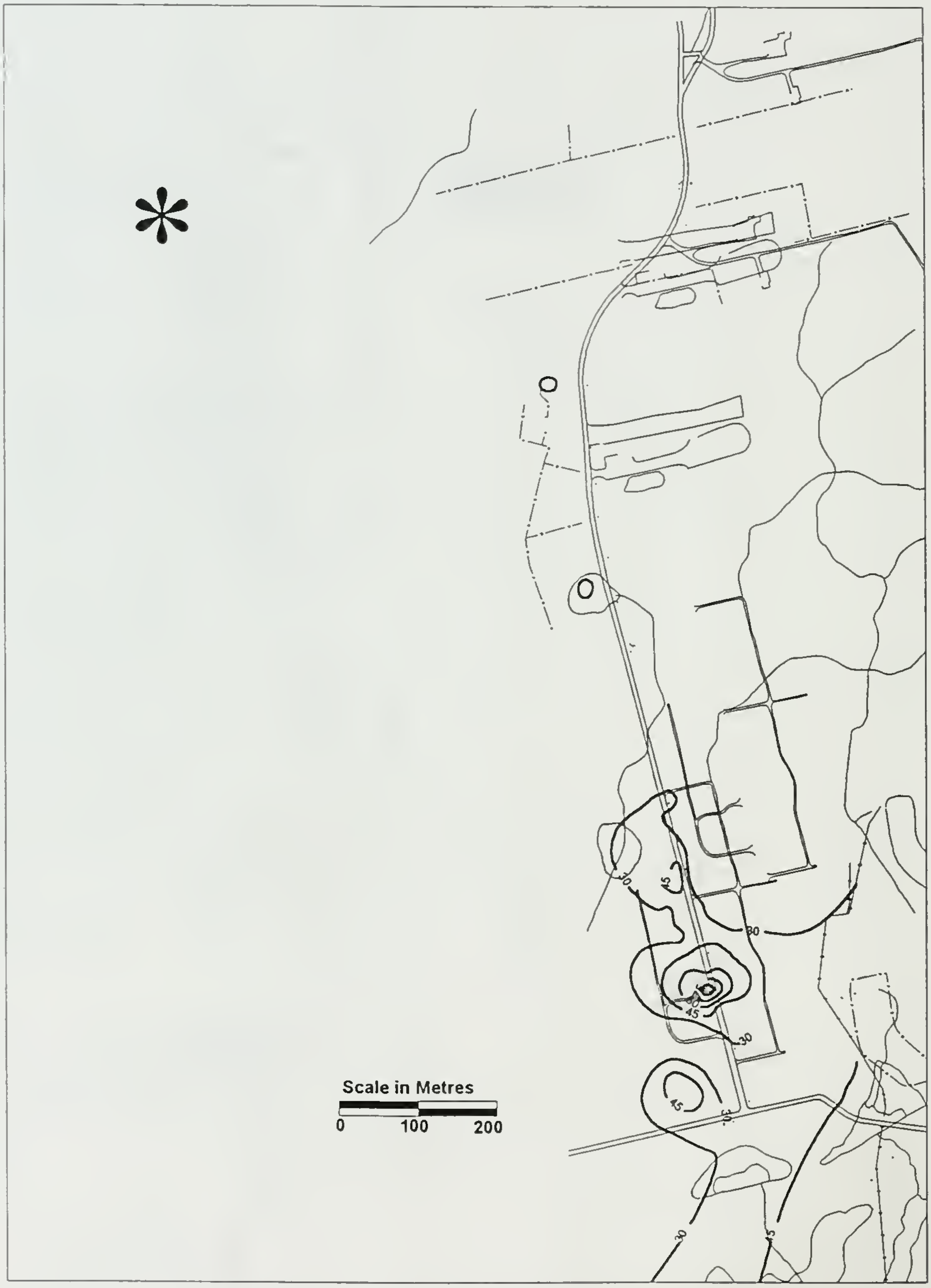
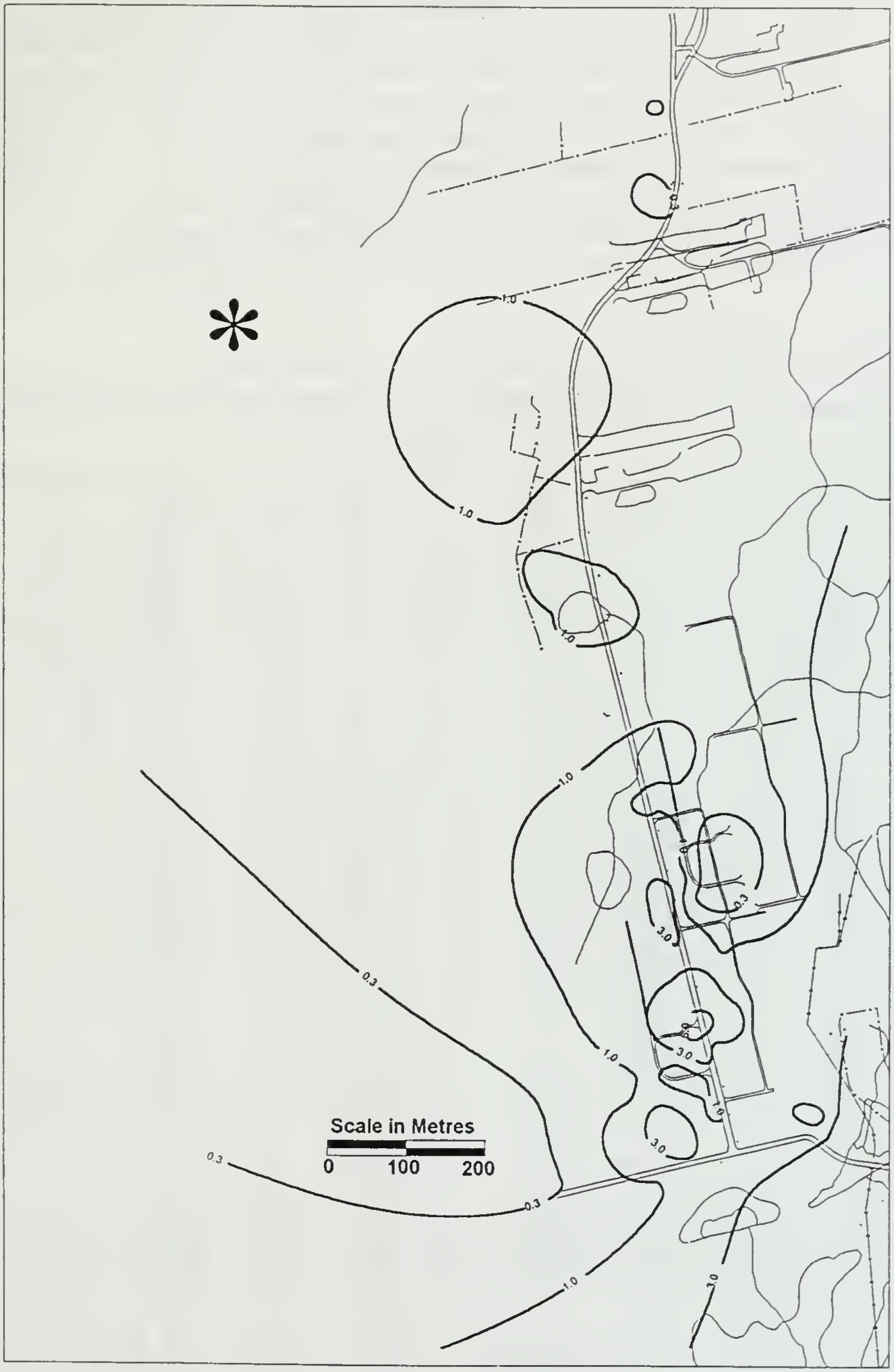


Figure 6: Concentration Contour Map of Silver ($\mu g/g$) in Soil Collected in the Vicinity of the Village of Deloro



Depth soil samples

Soil samples were taken at 0-5, 5-10 and 10-15 cm depths at 8 stations located throughout the village of Deloro (Table 2). It was recognized that disturbance of the soil through cultivation, excavation, or application of clean fill can greatly affect the pattern of soil contamination. Therefore, depth soil sampling stations were selected that appeared to have had no recent disturbance. At most of the stations, there was no pattern in contaminant distribution down the profile, which is reflected in the consistent overall mean values down the profile. There appears to be a possible trend in the overall arsenic mean values with depth, but this was not statistically significant. As with the surface samples, metal concentrations between duplicate samples were consistent. These data suggest that surface sampling of residential properties provides a good indication of the level of contamination to a depth of 15 cm, providing clean fill has not covered historically contaminated soil.

Table 2: The average metal concentrations (μg/g dry weight) in duplicate soil samples taken at three depths from residential properties in the village of Deloro

		Station								
	Depth (cm)	154	174	216	226	240	246	254	265	Mean
Arsenic	0 - 5	160	240	65	74	85	170	83	415	161
	5 - 10	200	340	63	110	86	255	170	495	215
	10 - 15	220	260	62	120	220	290	250	460	235
Barium	0 - 5	160	255	160	150	130	275	105	275	189
	5 - 10	190	290	160	200	130	265	160	290	211
	10 - 15	190	290	155	190	200	270	190	305	224
Cobalt	0 - 5	44	156	19	45	58	73	26	270	86
	5 - 10	51	110	18	58	63	79	45	135	70
	10 - 15	54	78	17	61	120	77	50	44	62
Copper	0 - 5	30	56	17	29	18	34	18	49	31
	5 - 10	35	55	16	34	18	39	29	32	32
	10 - 15	40	100	19	35	42	41	36	19	41
Lead	0 - 5	155	195	29	128	125	105	39	220	124
	5 - 10	180	230	30	160	110	125	63	90	123
	10 - 15	260	170	24	160	250	145	81	31	140
Nickel	0 - 5	39	99	22	47	37	56	23	140	58
	5 - 10	44	79	20	57	48	60	40	108	57
	10 - 15	44	69	19	62	76	66	44	49	54
Silver	0 - 5	4.0	8.6	0.8	3.4	4.2	4.8	1.4	20.5	5.9
	5 - 10	4.9	9.3	0.7	4.1	5.7	5.4	2.8	9.3	5.3
	10 - 15	5.1	6.3	0.8	5.1	10.0	5.9	3.3	3.4	5.0
Strontium	0 - 5	30	39	29	29	22	28	19	31	28
	5 - 10	38	42	27	31	23	30	28	31	31
	10 - 15	43	47	26	32	41	35	33	31	36
Uranium	0 - 5	0.468	0.648	0.319	0.321	0.445	0.484	0.328	1.410	0.553
	5 - 10	0.522	0.556	0.307	0.437	0.712	0.418	0.342	1.355	0.581
	10 - 15	0.517	0.506	0.281	0.484	0.492	0.455	0.421	0.764	0.490
Zinc	0 - 5	120	210	78	137	96	120	69	120	119
	5 - 10	140	240	66	170	95	120	93	91	127
	10 - 15	140	210	80	170	200	115	96	68	135

Radionuclide data

The results of radionuclide analysis (Appendix 5) are typical of soil radionuclide concentrations in southern Ontario (Ken Gilmer, pers. comm.) and the mean Ra-226 value for these data is slightly below the mean background value for Ra-226 in Ontario soils (Clement, 1997).

Garden study

Overall, the soils collected from the gardens had lower concentrations of metals (Table 3) than the soils collected from residential properties (Table 1). This is not simply due to sampling at a depth of 0-15 cm in the gardens compared to 0-5 cm for the residential properties, since the results of depth sampling on selected residential properties suggested that there was no pattern in metal concentration with depth. The selected gardens represent most of the vegetable gardens in the village of Deloro, and they tended not be located in the most contaminated areas of the village. There was a slight elevation of barium, lead, nickel, silver, and zinc concentrations in some gardens relative to their respective OTR98 values and in one garden (Garden E) the soil lead concentration exceeded the MOE soil clean-up guideline of 200 μg/g.

Plants used in the garden study were chosen to represent root crops (carrots and beets) and leaf crops (lettuce). Beans were chosen because bean plants are known to be very sensitive to arsenic. The variety of beans used in the Deloro study was also used in a study of arsenic contaminated coarse textured old orchard soils, conducted at the Phytotoxicology laboratory. The beans in the orchard soils had significant growth reductions at soil arsenic concentrations of 20 μg/g . In contrast, the bean plants in all but one of the Deloro gardens appeared healthy with good pod production, even though arsenic concentrations ranged up to 100 μg/g. This suggests that the arsenic in the Deloro garden soils was not readily available, which may be due to finer soil texture, higher organic matter content, higher phosphorus concentrations in these soils than in the orchard soils tested or that the arsenic was in an insoluble form, such as a sulphate or pyrite.

In general, there was relatively little uptake of any of the elements analysed in any of the plant species. Most plant tissue concentrations were comparable to tissue concentrations in the control plants (Tables 4a to d). A notable exception was for carrot roots from Gardens A and B, which had much higher lead concentrations and marginally higher arsenic, barium, cobalt, nickel, strontium, and zinc concentrations than other garden sites. Re-analysis of these roots confirmed these results. The high uptake of lead into the carrot roots could not be simply attributed to soil lead concentrations since the garden with the highest soil lead concentration (Garden E) had relatively low lead uptake into the carrot roots. Even in the two gardens where the average lead concentration in carrot roots was high (Gardens A and B), there was high variability between duplicate samples. It is unknown why lead uptake was so variable within some gardens and why it was not related to soil lead concentrations. In all gardens, the arsenic concentrations in lettuce leaves were above that of the control. However, even the arsenic concentration of 3.5 μg/g in lettuce leaves from Garden A was below the arsenic concentration of 5.5 μg/g noted in lettuce leaves in the 1986/87 garden data, a concentration which was not considered a level of concern (MOE, 1998). None of the other metals were considered elevated in any of the crops. There were no results for beet roots from Garden B (Table 4b) due to poor beet growth, resulting in insufficient material to sample. The poor growth was attributed to a lack of water.

Table 3a: Average concentration of metal in duplicate soil samples (0-15 cm) taken from gardens in the vicinity of the Deloro Mine Site (μg/g dry weight), April 1998.

Garden	Arsenic	Barium	Cobalt	Copper	Lead	Nickel	Silver	Strontium	Uranium	Zinc
A	42	130	24	19	34	24	1.4	62	0.263	63
B	82	140	41	28	150	35	2.3	33	0.304	145
C	63	135	19	20	16	24	1.0	32	0.237	69
D	18	102	7	18	18	12	0.2	120	0.540	49
E	100	350	74	59	265	61	4.5	80	0.256	380
F	36	135	16	18	17	21	0.5	22	0.270	71
G	30	125	13	14	18	18	0.5	35	0.325	71
mean	**53**	**160**	**28**	**25**	**74**	**28**	**1.5**	**55**	**0.312**	**121**
median	**42**	**135**	**19**	**19**	**18**	**24**	**1.0**	**35**	**0.270**	**71**
minimum	**18**	**102**	**7**	**14**	**16**	**12**	**0.2**	**22**	**0.231**	**49**
maximum	**100**	**350**	**74**	**59**	**265**	**61**	**4.5**	**120**	**0.540**	**380**
OTR98	**17**	**180**	**17**	**65**	**98**	**32**	**0.3**	**78**	**1.400**	**140**
Table A(f)	**25**	**1000**	**50**	**300**	**200**	**200**	**25.0**	**NG**	**NG**	**800**
Table A(c)	**20**	**750**	**40**	**225**	**200**	**150**	**20.0**	**NG**	**NG**	**600**

† 98[th] percentile of the Ontario Typical Range (see Appendix 4)
Table A (f) - Surface soil remediation criteria for fine textured residential sites in a potable groundwater situation (MOE, 1997)
Table A (c) - Surface soil remediation criteria for coarse textured residential sites in a potable groundwater situation (MOE, 1997)
NG - no guideline

Table 3b: Average concentration of elements in duplicate soil samples (0-15 cm) taken from gardens in the vicinity of the Deloro Mine Site (μg/g dry weight), April 1998.

Garden	Aluminum	Beryllium	Cadmium	Calcium	Chromium	Iron	Magnesium	Manganese	Molybdenum	Vanadium
A	18000	0.7 <T	0.2 <W	31000	26	22000	5750	595	0.5 <W	39
B	12000	0.5 <W	0.2 <W	9000	23	18500	4950	505	0.5 <W	36
C	14000	0.6 <T	0.25 <T	8800	23	21000	5250	990	0.5 <W	34
D	11000	0.5 <W	0.2 <W	125000	17	13000	8450	475	0.5 <W	25
E	20000	0.8 <T	1.2 <T	20000	41	25500	6750	1100	0.5 <W	47
F	20500	0.7 <T	0.35 <T	6750	31	25500	6150	1200	0.5 <W	50
G	18000	0.6 <T	0.45 <T	9400	38	23000	5200	1100	0.5 <W	43
mean	16214	0.6	0.4	29993	28	21214	6071	852	0.5	39
median	18000	0.6	0.3	9400	26	22000	5750	990	0.5	39
minimum	11000	0.5	0.2	6750	17	13000	4950	475	0.5	25
maximum	20500	0.8	1.2	125000	41	25500	8450	1200	0.5	50
OTR98	27000	0.97	0.84	58000	62	33000	16000	1300	0.85	71
Table A(f)	NG	1.2	12.0	NG	1000	NG	NG	NG	40	250
Table A(c)	NG	1.2	12.0	NG	750	NG	NG	NG	40	250

† 98[th] percentile of the Ontario Typical Range (see Appendix 4)
Table A (f) - Surface soil remediation criteria for fine textured residential sites in a potable groundwater situation (MOE, 1997)
Table A (c) - Surface soil remediation criteria for coarse textured residential sites in a potable groundwater situation (MOE, 1997)
<W - no measurable response (zero); <T - trace amount: interpret with caution; NG - no guideline

Table 4a: The average concentration of elements from duplicate samples of bean pods grown in Deloro gardens (μg/g dry weight), July 1998.

Garden	Arsenic	Barium	Boron	Cadmium	Cobalt	Copper	Lead	Molybdenum	Nickel	Strontium	Uranium	Zinc
A	0.2 ≤W	5.3	17	0.1 ≤W	0.3 ≤W	7	0.5 ≤W	3.0	0.9 <T	13.0	0.001	24
B	0.2 ≤W	6.8	16	0.1 ≤W	0.2 ≤W	7	0.5 ≤W	2.8	1.4 <T	11.5	0.010	25
C	0.2 ≤W	3.0	16	0.1 ≤W	0.2 ≤W	6	0.5 ≤W	0.9	1.0 <T	8.0	0.000	23
D	0.2 ≤W	9.6	18	0.1 ≤W	0.2 ≤W	7	0.5 ≤W	2.4	0.9 <T	17.5	0.000	25
E	0.2 ≤W	6.5	18	0.1 ≤W	0.2 ≤W	8	0.5 ≤W	2.7	1.4 <T	16.5	0.001	31
F	0.2 ≤W	3.6	20	0.1 ≤W	0.2 ≤W	10	0.5 ≤W	0.6 <T	0.8 <T	8.7	0.002	39
G	0.2 ≤W	1.8	21	0.1 ≤W	0.2 ≤W	8	0.5 ≤W	2.3	0.6 <T	11.0	0.001	30
Mean		**5.2**	**18**	**0.1**	**0.2**	**8**	**0.5**	**2.1**	**1.0**	**12.3**	**0.002**	**28**
Control	**0.2 ≤W**	**1.7**	**23**	**0.1 ≤W**	**0.2 ≤W**	**11**	**0.5 ≤W**	**2.9**	**0.6 ≤W**	**12.0**	**0.003**	**36**

≤W - no measurable response (zero); <T - trace amount: interpret with caution

Table 4b: The average concentration of elements from duplicate samples of beet roots grown in Deloro gardens (μg/g dry weight), July 1998.

Garden	Arsenic	Barium	Boron	Cadmium	Cobalt	Copper	Lead	Molybdenum	Nickel	Strontium	Uranium	Zinc
A	1.2	33.0	17	0.1 ≤W	0.3 <T	12	0.5 ≤W	0.2 ≤W	0.5 ≤W	19.0	0.002	35
C	0.5 <T	26.0	15	0.1 ≤W	0.3 <T	12	0.5 ≤W	0.3 <T	0.5 ≤W	13.0	0.006	31
D	0.4 <T	44.5	17	0.1 ≤W	0.2 ≤W	13	0.7 <T	0.3	0.5 ≤W	18.5	0.004	40
E	0.6 <T	35.5	15	0.3 <T	0.5 <T	13	0.8 <T	0.3 <T	0.6 <T	15.5	0.007	46
F	0.3 <T	18.0	16	0.2 <T	0.3 <T	12	0.5 ≤W	0.2 ≤W	0.5 ≤W	9.7	0.004	27
G	0.2 ≤W	27.5	17	0.2 <T	0.2 ≤W	13	0.6 <T	0.3 <T	0.5 ≤W	18.5	0.004	43
Mean	**0.4**	**26.4**	**14**	**0.1**	**0.2**		**0.5**	**0.2**	**0.5**	**13.5**	**0.004**	**31**
Control	**0.2 ≤W**	**26.5**	**17**	**0.1 ≤W**	**0.3 ≤W**	**13**	**0.5 ≤W**	**0.2 ≤W**	**0.6 <T**	**19.5**	**0.006**	**33**

≤W - no measurable response (zero); <T - trace amount: Interpret with caution

Table 4c: The average concentration of elements from duplicate samples of carrot roots grown in Deloro garden (μg/g dry weight), July 1998.

Garden	Arsenic	Barium	Boron	Cadmium	Cobalt	Copper	Lead	Molybdenum	Nickel	Strontium	Uranium	Zinc
A	0.4 <T	17.0	21	0.1 ≤W	0.3 <T	8	16.2 <T	0.2 ≤W	16.6 <T	18.0	0.005	24
B	2.0	26.5	26	0.1 ≤W	0.7 <T	6	35.5	0.3 ≤W	20.5	21.5	0.005	35
C	0.6 <T	9.8	18	0.1 ≤W	0.2 ≤W	6	0.5 ≤W	0.2 ≤W	0.6 <T	11.0	0.009	19
D	0.5 <T	13.0	25	0.1 ≤W	0.2 ≤W	5	1.4 <T	0.2 ≤W	0.6 <T	17.5	0.005	20
E	1.3	13.0	19	0.2 <T	0.5 <T	8	1.3 <T	0.2 ≤W	0.9 <T	12.5	0.011	26
F	0.2 ≤W	7.0	20	0.2 <T	0.2 ≤W	7	0.5 ≤W	0.2 ≤W	0.5 ≤W	8.9	0.003	15
G	0.2 ≤W	11.0	22	0.2 <T	0.2 ≤W	8	0.5 ≤W	0.2 ≤W	0.5 ≤W	12.0	0.005	19
Mean	**0.7**	**13.9**	**22**	**0.2**	**0.3**	**7**	**7.9**	**0.2**	**5.7**	**14.5**	**0.006**	**23**
Control	**0.2 ≤W**	**8.3**	**26**	**0.2 <T**	**0.2 ≤W**	**9**	**0.5 ≤W**	**0.3 ≤W**	**15.3**	**17.5**	**0.005**	**33**

≤W - no measurable response (zero); <T - trace amount: interpret with caution

N.B. - due to high variability in the data, the average lead concentrations for Gardens A and B must be interpreted with caution. The values used to calculate the mean for Garden A were 1.4 μg/g and 31 μg/g and for Garden B were 13 μg/g and 58 μg/g.

Table 4d: The average concentration of elements from duplicate samples of lettuce leaves grown in Deloro gardens (μg/g dry weight), July 1998.

Garden	Arsenic	Barium	Boron	Cadmium	Cobalt	Copper	Lead	Molybdenum	Nickel	Strontium	Uranium	Zinc
A	3.5	14.0	21	0.5 <T	0.5 <T	21	1.0 <T	0.5 <T	0.8 <T	38.5	0.012	29
B	1.3	18.0	22	0.3 <T	0.2 ≤W	13	1.7 <T	0.5 <T	0.5 ≤W	32.0	0.006	23
C	0.5 <T	9.3	21	0.4 <T	0.2 ≤W	12	0.5 ≤W	0.3 <T	0.6 <T	24.5	0.009	24
D	0.6 <T	16.0	25	0.2 <T	0.2 ≤W	12	0.5 ≤W	0.4 <T	0.5 ≤W	37.0	0.003	38
E	2.3	13.4	24	0.5 <T	0.6 <T	23	1.4 <T	0.5 <T	0.9 <T	30.0	0.016	40
F	0.6 <T	16.0	24	0.5 <T	0.9	15	4.2	0.4 <T	1.4 <T	30.5	0.009	40
G	0.3 <T	3.9	19	0.5 <T	0.2 ≤W	8	0.6 <T	0.4 <T	0.5 ≤W	18.5	0.004	29
Mean	**1.3**	**12.9**	**22**	**0.4**	**0.3**	**15**	**1.3**	**0.4**	**0.6**	**30.1**	**0.008**	**32**
Control	**0.2 ≤W**	**4.3**	**17**	**0.3 ≤W**	**0.2 ≤W**	**22**	**0.7 <T**	**0.2 ≤W**	**0.6 <T**	**28.0**	**0.014**	**37**

≤W - no measurable response (zero); <T - trace amount: interpret with caution

The radio nuclide concentrations in the seven garden soils (Table 5) are typical of soil radionuclide concentrations in southern Ontario (Ken Gilmer, pers. comm.) and the Ra-226 values are similar to the mean background value for Ra-226 in Ontario soils (Clement, 1997).

Table 5: Radionuclide values and percent moisture for soil samples collected from seven gardens in the village of Deloro, April 1998.

Garden	Moisture (%)	Cs -137 (Bq/g)*	K-40 (Bq/g)*	Ra-226 (Bq/g)*	Ra-228 (Bq/g)*	Th-228 (Bq/g)*	U-238 (Bq/g)*
A	2.1	<0.01	0.52	0.02	<0.05	0.04	<0.15
B	2	<0.01	0.99	0.03	<0.05	0.02	<0.15
C	1.4	<0.01	0.94	0.02	<0.05	<0.02	<0.15
D	1.6	<0.01	0.66	0.02	<0.05	<0.02	<0.15
E	2.5	<0.01	0.7	0.03	<0.05	<0.02	<0.15
F	2.4	<0.01	0.84	0.04	<0.05	0.03	<0.15
G	2.6	0.01	0.67	0.02	<0.05	0.02	<0.15
Background†	NA	NA	NA	0.025	NA	NA	NA

† mean background value for Ra-226 in Ontario soils (Clement, 1997)
NA - not available
* Bq/g - becquerels per gram

IV. Conclusions

Surface soil samples collected from residential properties in the village of Deloro were found to be significantly contaminated with arsenic, cobalt, and lead. Of the 145 stations sampled, 123, 59, and 25 exceeded the soil clean-up guideline for arsenic, cobalt and lead respectively. Maximum contaminant concentrations were 605 μg/g, 340 μg/g, and 655 μg/g for arsenic, cobalt and lead respectively. Barium, copper, nickel, silver, strontium, uranium, and zinc all exceeded their respective OTR98 values but none exceeded their respective soil clean-up guidelines for medium and fine textured soil.

Sampling of selected residential properties to a depth of 15 cm indicated there was no consistent pattern in contaminant concentration with depth.

Radionuclide data for residential properties were typical of values in southern Ontario soils and do not indicate cause for concern.

Soil samples from seven Deloro area gardens were found to be significantly contaminated with arsenic, and in one garden with lead, and marginally contaminated with cobalt, barium, lead, nickel, silver, strontium, and zinc. However, there was relatively little uptake of any of these contaminants into bean pods, beet roots, or lettuce leaves. Lead concentrations were inexplicably high in carrot roots from two gardens. Radionuclide concentrations in these garden soils were low and not a cause for concern.

The soil and vegetation data summarized in this report were used by MOE health risk assessment scientists to assist in their characterization of the potential risk to Deloro residents as a result of exposure to environmental contaminants.

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Appendix 1: Average metal concentrations in duplicate surface soil samples (0-5 cm) collected in the village of Deloro

Station	Arsenic	Barium	Cobalt	Copper	Lead	Nickel	Silver	Strontium	Uranium	Zinc
133	130	170	45	21	46	41	3.0	20	0.337	82
134	68	135	20	18	16	25	0.8	24	0.364	51
135	195	195	65	25	84	50	4.1	27	0.643	99
136	605	205	67	37	83	60	4.6	30	0.467	125
137	245	230	94	28	95	67	6.2	30	0.594	100
138	215	200	71	37	55	58	4.8	32	0.308	91
139	200	180	99	39	195	63	6.3	48	0.409	185
140	170	305	86	39	180	50	3.4	59	0.276	180
141	12	64	6	6	15	10	0.0	15	0.179	42
142	135	265	59	42	180	49	3.5	68	0.308	160
143	23	97	13	14	35	14	0.5	29	0.267	59
144	145	215	68	42	135	54	4.3	42	0.305	155
145	39	93	18	22	49	18	1.2	42	0.623	93
146	120	175	68	37	170	55	3.5	40	0.328	150
147	390	230	91	37	490	70	10.9	43	0.359	375
148	205	310	89	47	340	69	9.0	56	0.219	210
149	170	130	48	24	195	40	3.3	34	0.282	155
150	165	180	107	37	295	69	8.6	33	0.292	180
151	210	160	61	31	320	50	4.4	35	0.287	190
152	170	205	66	42	255	53	6.3	49	0.318	230
153	295	165	88	30	235	58	6.7	31	0.333	200
154	160	160	44	30	155	39	4.0	30	0.468	120
155	115	110	49	21	190	40	3.7	21	0.290	150
156	145	140	77	34	170	62	8.0	25	0.327	150
157	200	245	105	46	655	67	8.6	36	0.405	430
158	155	210	100	45	225	76	4.8	29	0.320	195
159	260	160	101	68	180	71	7.8	50	0.379	155
160	120	165	38	34	140	36	2.4	33	0.368	140
161	130	125	36	38	170	33	2.5	41	0.232	160
162	135	205	71	43	190	53	5.1	41	0.159	155
163	7	66	5	10	8	11	0.2	34	0.378	35
164	105	200	62	67	145	61	4.0	35	0.230	140
165	56	104	48	12	60	31	1.1	25	0.375	72
166	125	280	135	50	150	102	12.0	56	0.284	195
167	84	140	31	25	255	28	1.4	35	0.323	185
168	140	195	110	51	110	71	7.8	34	0.353	125
169	29	105	15	24	105	17	0.6	39	0.441	120
170	130	220	130	56	315	88	13.0	58	0.246	265
171	220	155	32	28	130	34	2.5	96	0.546	115
172	150	245	110	45	135	73	8.7	55	0.326	160
173	94	105	31	17	71	27	2.0	16	0.276	69
174	240	255	156	56	195	99	8.6	39	0.648	210
175	91	99	27	18	107	25	1.6	67	0.545	109
176	43	115	56	35	74	53	1.5	25	0.286	103
177	225	135	35	18	93	33	2.0	25	0.304	96
178	26	93	14	15	46	20	0.9	26	0.288	75
179	120	135	46	23	96	42	2.9	22	0.270	125
180	175	185	120	115	250	94	7.4	32	0.292	220
181	10	76	8	12	16	12	0.4	23	0.432	59
182	3	170	22	22	19	34	0.8	36	0.348	79
183	8	120	7	18	9	15	0.1	98	0.551	53
184	43	150	11	17	150	18	0.5	77	0.287	86
185	24	173	14	16	17	21	0.4	32	0.346	60
186	25	175	14	15	16	20	0.5	31	0.389	58
187	43	72	29	12	15	23	1.9	73	0.248	49

Station	Arsenic	Barium	Cobalt	Copper	Lead	Nickel	Silver	Strontium	Uranium	Zinc
188	81	175	87	43	105	65	6.1	42	0.313	205
189	49	150	20	16	23	24	0.7	22	0.352	80
190	16	72	8	11	12	11	0.2	47	0.478	40
191	85	135	29	19	52	31	1.5	32	0.343	110
192	112	260	44	44	465	36	3.9	103	0.247	355
193	71	110	24	19	34	27	1.2	26	0.266	74
194	55	200	21	31	67	29	1.1	38	0.364	150
195	79	105	47	18	36	32	1.9	30	0.331	115
196	75	205	150	37	97	48	8.4	51	0.361	255
197	19	61	8	10	12	14	0.3	18	0.269	33
198	11	53	8	10	8	11	0.3	20	0.320	39
199	31	125	17	11	15	21	0.6	18	0.306	60
200	19	115	13	15	13	19	0.4	22	0.298	165
201	58	120	24	18	30	31	1.3	28	0.298	94
202	73	145	45	29	111	41	2.2	32	0.381	190
203	14	68	10	9	12	14	0.3	16	0.426	60
204	36	96	23	17	25	23	1.1	43	0.436	88
205	35	105	18	11	22	21	1.0	16	0.358	72
206	49	115	33	17	64	28	3.3	22	0.433	130
207	59	105	22	15	33	27	1.4	40	0.249	82
208	36	135	21	14	115	22	1.0	32	0.279	110
209	52	110	20	18	18	26	1.0	25	0.278	66
210	76	130	25	18	19	30	1.4	23	0.251	63
211	11	69	9	12	11	16	0.4	21	0.511	46
212	41	110	21	18	19	26	1.1	20	0.333	64
213	25	110	11	14	9	16	0.4	19	0.301	41
214	53	135	21	19	21	23	1.1	48	0.228	57
215	62	110	22	18	23	26	1.2	18	0.231	58
216	65	160	19	17	29	22	0.8	29	0.319	78
217	215	170	165	28	150	68	7.4	21	0.266	165
218	183	140	90	43	93	51	4.4	29	0.293	125
219	110	145	51	21	130	39	4.2	23	0.259	135
220	74	120	56	23	115	43	5.7	24	0.276	125
221	120	145	52	20	135	40	3.2	23	0.409	165
222	61	170	41	33	83	39	2.6	28	0.280	99
223	81	130	34	22	87	30	2.4	30	0.406	96
224	71	230	71	51	165	50	6.8	32	0.504	180
225	39	109	26	19	43	24	1.3	32	0.285	98
226	74	150	45	29	128	47	3.4	29	0.321	137
227	145	190	90	51	130	66	6.6	35	0.289	130
228	155	195	145	60	98	110	9.5	35	0.273	125
229	290	180	105	40	250	79	7.8	29	0.393	205
230	110	270	170	73	345	97	8.5	52	0.312	225
231	175	210	78	43	180	69	6.7	62	0.381	155
232	73	120	46	25	83	39	3.0	64	0.470	130
233	31	91	24	31	89	25	1.0	32	0.345	89
234	78	230	115	58	165	100	6.8	48	0.428	135
235	61	125	40	29	97	36	2.5	28	0.406	105
236	160	235	155	50	190	110	9.5	43	0.455	195
237	225	170	135	43	220	84	12.5	38	1.170	175
238	595	285	340	93	470	195	7.2	51	0.530	385
239	15	46	7	11	29	9	0.9	26	0.804	42
240	85	130	58	18	125	37	4.2	22	0.445	96
241	15	65	10	10	26	13	0.7	22	0.301	49
242	135	170	67	33	110	56	5.9	27	0.374	125
243	150	200	93	37	285	74	6.6	67	0.463	190
244	91	240	67	48	215	55	9.3	58	0.350	185

Station	Arsenic	Barium	Cobalt	Copper	Lead	Nickel	Silver	Strontium	Uranium	Zinc
245	310	250	130	46	445	84	9.2	68	0.548	245
246	170	275	73	34	105	56	4.8	28	0.484	120
247	310	255	155	53	480	105	9.8	65	0.441	270
248	265	405	190	71	385	135	10.1	62	0.560	265
249	140	195	103	38	165	72	7.0	45	0.670	165
250	115	285	150	52	205	92	8.7	36	0.831	235
251	73	125	59	25	88	43	4.0	29	0.371	110
252	70	175	44	30	73	39	2.9	31	0.348	105
253	68	98	43	15	91	34	3.1	20	0.437	104
254	83	105	26	18	39	23	1.4	19	0.328	69
255	61	115	22	20	56	28	1.3	36	0.370	72
256	45	70	20	10	46	17	1.3	24	0.297	62
257	112	185	28	23	97	30	1.7	52	0.271	83
258	35	110	9	10	7	14	0.5	25	0.339	25
259	37	225	18	21	22	26	0.8	39	0.406	78
260	6	58	8	8	17	12	0.4	17	0.517	49
261	41	140	17	19	200	23	1.0	17	0.266	93
262	91	145	31	26	220	24	2.4	52	0.399	89
263	330	260	120	36	72	90	8.9	28	0.833	120
264	335	385	155	37	89	105	11.5	38	0.397	110
265	415	275	270	49	220	140	20.5	31	1.410	120
266	29	55	19	11	28	18	0.7	14	0.266	55
267	58	80	20	12	20	21	1.4	15	0.320	47
275	22	165	20	23	105	24	0.6	45	0.390	130
276	45	275	36	38	160	30	2.5	93	0.319	275
277	25	95	13	19.5	21	16	0.3	20	0.311	64
278	18	150	13	14	22	18	0.3	27	0.309	68
279	53	210	27	23	62	29	1.2	33	0.292	120
280	47	315	27	29.5	140	28	1.1	87	0.291	290
281	2	375	5	8	4	11	0.1	56	0.197	25
282	17	125	10	8	13	16	0.2	21	0.258	79
283	13	120	11	9.5	14	18	0.1	17	0.303	57
284	17	130	11	13.5	15	19	0.2	27	0.289	102
mean	**111**	**163**	**57**	**29**	**121**	**44**	**3.7**	**36**	**0.376**	**128**
median	**78**	**150**	**41**	**24**	**95**	**34**	**2.5**	**32**	**0.331**	**115**
minimum	**2**	**46**	**5**	**6**	**4**	**9**	**0.0**	**14**	**0.159**	**25**
maximum	**605**	**405**	**340**	**115**	**655**	**195**	**20.5**	**103**	**1.410**	**430**
OTR98†	**17**	**180**	**17**	**65**	**98**	**32**	**0.3**	***78***	***1.400***	**140**
Table A (f)	**25**	**1000**	**50**	**300**	**200**	**200**	**25.0**			**800**
Table A (c)	**20**	**750**	**40**	**225**	**200**	**150**	**20.0**			**600**
Exceedance★	**123**	**0**	**59**	**0**	**25**	**0**	**0**	**0**	**0**	**0**

† 98th percentile of the Ontario Typical Range (Appendix 4)
Table A (f) - Surface soil remediation criteria for medium and fine textured residential sites in a potable groundwater situation (MOE, 1997)
Table A (c) - Surface soil remediation criteria for coarse textured residential sites in a potable groundwater situation (MOE, 1997)
≤W - no measurable response (zero); <T - trace amount: interpret with caution
★ - the number of stations out of 145 that exceeded the soil clean-up guideline (Table A (f)).

Appendix 2: Average concentration of elements in duplicate surface soil samples (0-5 cm) collected in the village of Deloro

Station	Aluminum	Beryllium	Cadmium	Calcium	Chromium	Iron	Magnesium	Manganese	Molybdenum	Vanadium
133	19500	0.8 <T	0.3 <T	7700	34	25000	7700	1030	0.5 ≤W	44
134	19000	0.8 <T	0.2 ≤W	6550	30	24000	7100	895	0.5 ≤W	44
135	19500	0.8 <T	0.4 <T	7400	38	25000	6900	1080	0.5 ≤W	44
136	19500	0.8 <T	0.4 <T	10750	47	26000	7800	1300	0.5 ≤W	43
137	20500	0.8 <T	0.4 <T	11000	40	25500	7950	1100	0.5 ≤W	44
138	21000	0.8 <T	0.5 <T	9200	37	25500	7900	1200	0.5 ≤W	41
139	16500	0.7 <T	0.6 <T	23500	36	25000	8300	915	0.5 ≤W	37
140	25000	1.0 <T	0.4 <T	16000	45	29500	10500	1200	0.5 ≤W	51
141	11500	0.5 ≤W	0.2 ≤W	4150	20	18500	3650	390	0.5 ≤W	34
142	24500	0.9 <T	0.4 <T	24000	44	30000	11500	1100	0.5 ≤W	49
143	12000	0.5 ≤W	0.2 ≤W	11500	21	20500	4900	700	0.5 ≤W	41
144	20500	0.8 <T	0.4 <T	12500	36	27000	8850	940	0.5 ≤W	45
145	10500	0.5 ≤W	0.2 ≤W	17000	21	17500	5200	500	0.5 ≤W	31
146	18000	0.7 <T	0.2 ≤W	12500	31	24000	6800	745	0.5 ≤W	41
147	19500	0.8 <T	0.9 <T	23500	39	25500	9000	1300	0.5 ≤W	42
148	25000	1.0 <T	0.6 <T	22500	46	28000	11500	1150	0.5 ≤W	44
149	19000	0.8 <T	0.7 <T	17500	36	22000	7550	955	0.5 ≤W	42
150	17500	0.7 <T	0.7 <T	9500	38	23000	6550	900	0.5 ≤W	44
151	18500	0.7 <T	0.8 <T	16000	36	24500	7100	935	0.5 ≤W	48
152	19000	0.8 <T	0.7 <T	12500	35	25000	6600	1000	0.5 ≤W	47
153	17500	0.7 <T	0.7 <T	11500	35	24500	6150	940	0.5 ≤W	47
154	16000	0.7 <T	0.3 <T	7950	30	23000	5450	960	0.5 ≤W	46
155	15500	0.6 <T	0.4 <T	7050	27	21500	4800	600	0.5 ≤W	41
156	14000	0.6 <T	0.8 <T	7850	27	20000	4450	805	0.5 ≤W	39
157	16500	0.7 <T	1.5	15000	37	24000	6350	980	0.5 ≤W	41
158	19500	0.9 <T	1.0	8000	37	23500	6050	1250	0.5 ≤W	45
159	21500	0.9 <T	1.1	28000	42	27500	9800	1300	0.5 ≤W	46
160	18000	0.8 <T	0.5 <T	10000	32	24500	6600	945	0.5 ≤W	46
161	23000	0.7 <T	1.0	25500	28	24000	6950	905	0.5 ≤W	37
162	22000	1.1 <T	0.9 <T	13000	38	25000	7800	1300	0.5 ≤W	45
163	9550	0.5 ≤W	0.2 ≤W	17500	26	17000	4700	415	0.5 ≤W	39
164	20000	1.0 <T	0.7 <T	12500	34	23500	7150	1250	0.6 ≤W	42
165	12000	0.5 ≤W	0.6 <T	5750	20	18000	4050	505	0.5 ≤W	36
166	17500	0.9 <T	1.0	13000	31	22000	6300	1250	0.5 ≤W	38
167	13500	0.6 <T	0.7 <T	11500	23	22000	5300	670	0.5 ≤W	36
168	15500	0.8 <T	0.6 <T	10200	26	20500	5350	880	0.5 ≤W	34
169	12500	0.5 ≤W	0.8 <T	12500	22	20000	4600	570	0.6 ≤W	35
170	14500	0.7 <T	1.0	16500	32	20500	6200	845	0.5 ≤W	35
171	12000	0.6 <T	0.6 <T	20000	23	20000	6000	730	0.5 ≤W	34
172	18500	0.8 <T	0.7 <T	21500	32	21000	7650	1050	0.5 ≤W	35
173	12500	0.6 <T	0.5 <T	6000	24	19000	4500	660	0.5 ≤W	35

Station	Aluminum	Beryllium	Cadmium	Calcium	Chromium	Iron	Magnesium	Manganese	Molybdenum	Vanadium
174	21500	0.9 <T	0.6 <T	15500	38	23000	6900	905	0.5 ≤W	43
175	11000	0.5 ≤W	0.7 <T	11500	21	17500	4050	630	0.5 ≤W	31
176	15000	0.6 <T	0.6 <T	8500	26	21500	5750	720	0.6 ≤W	38
177	14500	0.6 <T	0.5 <T	11500	26	19500	5400	970	0.5 ≤W	34
178	12500	0.5 ≤W	0.4 <T	13000	21	18500	5650	570	0.5 ≤W	34
179	18000	0.8 <T	0.8 <T	10200	31	22000	5700	1250	0.5 ≤W	38
180	19000	0.8 <T	1.0 <T	13500	36	24000	6350	930	0.5 ≤W	43
181	10500	0.5 ≤W	0.3 <T	7050	19	18500	3950	425	0.5 ≤W	37
182	17000	0.6 <T	0.4 <T	9050	31	23000	6400	590	0.5 ≤W	46
183	12500	0.5 ≤W	0.4 <T	102000	24	17000	7150	470	0.5 ≤W	35
184	16500	0.7 <T	0.6 <T	73000	26	19000	7050	545	0.5 ≤W	36
185	17000	0.7 <T	0.5 <T	12000	30	24000	6300	665	0.5 ≤W	47
186	16500	0.7 <T	0.3 <T	11500	29	23500	6000	620	0.5 ≤W	48
187	9800	0.5 ≤W	0.2 ≤W	49000	18	15500	4000	495	0.5 ≤W	30
188	16000	0.6 <T	0.9 <T	19500	32	23000	6400	815	0.5 ≤W	43
189	19500	0.8 <T	0.6 <T	8700	29	27000	5750	1550	0.5 ≤W	48
190	9200	0.5 ≤W	0.3 <T	7700	16	16500	3250	585	0.5 ≤W	34
191	22500	0.8 <T	0.5 <T	15500	33	25500	6200	1200	0.5 ≤W	49
192	15500	0.6 <T	1.1 <T	61500	29	18500	4950	1200	0.5 ≤W	32
193	18500	0.8 <T	0.2 ≤W	14500	29	23000	5000	1250	0.5 ≤W	41
194	21500	0.9 <T	0.4 <T	11500	32	25500	5750	925	0.5 ≤W	47
195	19000	0.7 <T	0.3 ≤W	12500	29	24000	5500	1100	0.5 ≤W	46
196	19000	0.8 <T	1.0	17500	36	24500	5650	990	0.5 ≤W	44
197	12500	0.6 <T	0.2 ≤W	6950	21	20000	3850	525	0.5 ≤W	36
198	11500	0.6 <T	0.3 <T	9300	20	20500	4150	405	0.5 ≤W	39
199	20500	0.8 <T	0.7 <T	6350	31	25000	6100	1200	0.5 ≤W	50
200	18000	0.7 <T	0.5 <T	8100	28	25000	6250	855	0.5 ≤W	49
201	25000	1.0 <T	0.9 <T	12000	36	27000	6500	1450	0.5 ≤W	49
202	25500	0.9 <T	1.6	16500	41	29000	7050	1350	0.5 ≤W	51
203	14500	0.5 ≤W	0.4 <T	6300	22	21500	4050	655	0.5 ≤W	42
204	19000	0.7 <T	0.7 <T	15000	29	23000	5300	975	0.5 ≤W	45
205	19000	0.8 <T	0.8 <T	6700	29	24500	4950	1150	0.5 ≤W	45
206	19000	0.8 <T	1.0	8050	32	25500	5250	1100	0.5 ≤W	46
207	19500	0.8 <T	0.8 <T	25500	30	23000	5850	1200	0.5 ≤W	41
208	17000	0.6 <T	0.7 <T	16500	28	24000	5050	815	0.5 ≤W	48
209	19000	0.7 <T	0.4 <T	10500	31	24000	7250	1100	0.5 ≤W	47
210	19500	0.8 <T	0.6 <T	10150	32	24000	7050	1250	0.5 ≤W	47
211	13000	0.5 ≤W	0.5 <T	7700	24	19500	5300	615	0.5 ≤W	40
212	17000	0.7 <T	0.4 <T	6800	28	21500	5350	800	0.5 ≤W	39
213	13500	0.5 ≤W	0.3 <T	6900	23	23000	5650	610	0.5 ≤W	47
214	18500	0.8 <T	0.3 <T	8700	29	22500	6600	935	0.5 ≤W	45
215	19000	0.8 <T	0.3 <T	5900	30	23500	6100	980	0.5 ≤W	45

Station	Aluminum	Beryllium	Cadmium	Calcium	Chromium	Iron	Magnesium	Manganese	Molybdenum	Vanadium
216	17000	0.7 <T	0.6 <T	5750	28	25000	5750	765	0.5 ≤W	51
217	16500	0.7 <T	0.8	6500	30	23500	5550	815	0.5 ≤W	44
218	13000	0.5 ≤W	0.3 <T	8550	33	23500	5150	565	0.5 ≤W	46
219	15500	0.7 <T	0.4 <T	6500	27	22000	5450	735	0.5 ≤W	44
220	14000	0.5 ≤W	0.2 ≤W	5600	27	23500	5100	595	0.5 ≤W	48
221	18000	0.7 <T	0.3 <T	7450	31	24500	6200	725	0.5 ≤W	49
222	21000	0.8 <T	0.4 <T	11500	33	26500	8150	995	0.5 ≤W	45
223	16000	0.6 <T	0.2 ≤W	13000	27	23500	6150	710	0.5 ≤W	47
224	21000	0.8 <T	0.6 <T	8700	35	26000	6550	1350	0.5 ≤W	44
225	16500	0.6 <T	0.2 ≤W	11000	26	23500	5900	820	0.5 ≤W	45
226	17500	0.7 <T	0.4 <T	7850	29	23000	5800	1000	0.5 ≤W	41
227	21500	0.8 <T	0.5 <T	13500	37	26500	7950	1100	0.5 ≤W	44
228	24500	0.9 <T	0.3 <T	9100	40	28500	8500	1150	0.5 ≤W	48
229	20500	0.8 <T	0.8 <T	10500	39	26000	7900	910	0.5 ≤W	46
230	23500	0.9 <T	0.7 <T	20000	44	26500	9100	1100	0.5 ≤W	44
231	21000	0.8 <T	0.7 <T	13500	36	25000	7500	1150	0.5 ≤W	44
232	16000	0.7 <T	0.3 <T	12000	28	21500	5950	740	0.5 ≤W	39
233	13500	0.6 <T	0.5 <T	16000	26	22000	5600	585	0.5 ≤W	36
234	22500	0.9 <T	0.9 <T	17000	37	24500	8000	1200	0.5 ≤W	44
235	16500	0.7 <T	0.6 <T	13000	29	23500	6300	805	0.5 ≤W	42
236	24000	0.9 <T	0.8 <T	13000	42	25500	7950	1100	0.5 ≤W	51
237	19000	0.8 <T	1.0	12500	42	24000	7100	1000	0.5 ≤W	43
238	17500	0.8 <T	1.5	16000	48	21500	6350	1000	0.5 ≤W	34
239	7550	0.5 ≤W	0.4 <T	11500	23	13000	3050	260	0.5 ≤W	28
240	15500	0.6 <T	0.3 <T	7700	30	21000	5650	615	0.5 ≤W	45
241	13000	0.5 ≤W	0.3 <T	10450	21	18500	4050	330	0.5 ≤W	36
242	22500	1.0 <T	0.6 <T	9700	39	24500	8100	1300	0.5 ≤W	46
243	23000	0.9 <T	1.1	24000	45	24500	8850	1250	0.7 ≤W	51
244	22500	0.9 <T	1.0	26500	41	24500	9950	1150	0.8 <T	47
245	20000	0.8 <T	1.7	25000	45	24500	8000	1350	0.5 ≤W	47
246	24000	1.0 <T	0.6 <T	8350	40	25500	7850	1450	0.5 ≤W	48
247	18500	0.8 <T	1.7	21000	49	25500	7550	1150	0.5 ≤W	47
248	25500	1.2 <T	1.2	16000	52	26500	8050	1900	0.5 ≤W	46
249	17000	0.7 <T	0.8 <T	18500	43	23500	7150	1150	0.5 ≤W	42
250	26500	1.2 <T	1.2	8950	65	29500	8750	1500	0.5 ≤W	47
251	14000	0.5 ≤W	0.5 <T	11000	27	21000	4850	700	0.5 ≤W	41
252	21500	0.9 <T	0.5 <T	8000	36	27000	7200	1200	0.5 ≤W	45
253	10500	0.5 ≤W	0.3 <T	5650	20	18000	3550	610	0.5 ≤W	36
254	15000	0.7 <T	0.4 <T	4450	24	20000	4500	910	0.5 ≤W	34
255	13500	0.5 ≤W	0.3 <T	10500	34	20500	6450	690	0.5 ≤W	41
256	10000	0.5 ≤W	0.3 <T	5550	19	20000	3150	385	0.5 ≤W	43
257	18500	0.8 <T	0.3 <T	36000	33	23000	9750	740	0.5 ≤W	44

Station	Aluminum	Beryllium	Cadmium	Calcium	Chromium	Iron	Magnesium	Manganese	Molybdenum	Vanadium
258	8200	0.5 ≤W	0.2 ≤W	11500	20	17500	4450	235	0.5 ≤W	38
259	20500	0.8 <T	0.3 <T	20500	37	28500	9200	785	0.5 ≤W	59
260	12000	0.5 ≤W	0.2 ≤W	5850	20	20500	4200	370	0.5 ≤W	44
261	15500	0.7 <T	0.4 <T	6850	27	22500	6100	705	0.5 ≤W	43
262	10450	0.5 ≤W	0.3 <T	21000	22	18500	4800	420	0.5 ≤W	36
263	20000	0.8 <T	1.0	7700	48	28000	7600	1000	0.5 ≤W	53
264	21500	0.9 <T	0.6 <T	7250	45	27500	7950	1100	0.5 ≤W	51
265	21000	1.0 <T	1.0	6600	58	26500	7150	1300	0.8 <T	47
266	10500	0.5 ≤W	0.2 ≤W	3800	19	16500	3150	345	0.5 ≤W	37
267	14000	0.6 <T	0.3 <T	4700	23	19000	4550	635	0.5 ≤W	40
275	18500	0.7 <T	0.8 <T	21000	32	24500	6450	1100	0.5 ≤W	46
276	17500	0.7 <T	1.1	27500	32	23000	5850	1200	0.5 ≤W	43
277	14500	0.5 ≤W	0.7 <T	7600	23	22500	4400	705	0.5 ≤W	45
278	17000	0.7 <T	0.6 <T	12000	28	25000	5800	1150	0.5 ≤W	51
279	20000	0.8 <T	0.9 <T	14000	42	26000	6200	1200	0.5 ≤W	51
280	19500	0.8 <T	1.2	29500	38	25500	6400	1550	0.5 ≤W	48
281	9300	0.5 ≤W	0.3 ≤W	50000	19	20500	6800	220	0.5 ≤W	39
282	16500	0.8 <T	0.7 <T	16000	26	25000	5550	410	0.5 ≤W	46
283	18000	0.9 <T	0.7 <T	5550	28	22000	5650	1250	0.5 ≤W	41
284	18000	0.8 <T	0.6 <T	6000	28	25500	6200	705	0.5 ≤W	48
mean	**17359**	**0.7**	**0.6**	**14333**	**31**	**23079**	**6311**	**907**	**0.5**	**43**
median	**18000**	**0.7**	**0.6**	**11500**	**31**	**23500**	**6200**	**930**	**0.5**	**44**
minimum	**7550**	**0.5**	**0.2**	**3800**	**16**	**13000**	**3050**	**220**	**0.5**	**28**
maximum	**26500**	**1.2**	**1.7**	**102000**	**65**	**30000**	**11500**	**1900**	**0.8**	**59**
OTR98†	**27000**	**0.97**	**0.84**	**58000**	**62**	**33000**	**16000**	**1300**	**0.85**	**71**
Table A (f)		1.2	12.0		1000				40	250
Table A (c)		1.2	12.0		750				40	200

† 98th percentile of the Ontario Typical Range (Appendix 4)
Table A (f) - Surface soil remediation criteria for medium and fine textured residential sites in a potable groundwater situation (MOE, 1997)
Table A (c) - Surface soil remediation criteria for coarse textured residential sites in a potable groundwater situation (MOE, 1997)
≤W - no measurable response (zero); <T - trace amount: interpret with caution

Appendix 3: Derivation and Significance of the MOEE Soil Remediation Criteria (Clean-up Guidelines)

The MOEE Soil Remediation Criteria have been developed to provide guidance in cleaning up contaminated soil. They are not action levels, in that an exceedence of one or more of the criteria does not automatically mean that a clean-up must be conducted. A site clean-up may be conducted when a contaminated property is sold and/or the land use is changed. For example, the owner of an industrial property who plans to sell his/her land to a developer who intends to build residential homes can use the Remediation Criteria to clean up the soil to meet the residential land use criteria. This will allow the site to be reused for residential land-use without concern for adverse effects.

When contamination is found at a site where a change in land-use is not planned, the criteria may be used to assist in making decisions about adverse effects and the need for remediation. This is different from the previously described situation where a decision to change the land-use has already been made and the level of remediation required to rule out the potential for adverse effects is established by the new land use. Decisions on the need to undertake remedial action when the criteria are exceeded, and where the land use is not changing, require consideration of factors such as:

- the demonstrated presence or likelihood of an adverse effect (on and off property);
- an understanding of the type of protection provided by the criteria gained through knowledge of the exposure pathways and receptors which were considered in the development of the criteria, and through understanding how that combination of pathways and receptors relate to those which could be found at the site;
- an understanding of the relationship between dose and health response for sensitive receptors from all exposure pathways, including the safety and uncertainty factors that have been used in the development of the criteria;
- an understanding of the environmental characteristics of the contaminants and of the site conditions that could influence the migration of the contaminants and how this effects their exposure and response characteristics.

In each case, the decision to undertake or not undertake site remediation should entail all of these factors plus any additional factors specific to the site in question. When the decision is made that remedial action is needed, the criteria can be used as clean-up targets. If these criteria are unacceptable to the proponent undertaking the remediation, they have an option to develop local back-ground-based criteria or conduct a site specific risk assessment.

The Soil Remediation Criteria are effects-based concentrations set to protect against the potential for adverse effects to human health, ecological health, and the natural environment, whichever is the most sensitive. By protecting the most sensitive parameter the rest of the environment is protected by default. There are different Soil Remediation Criteria for soil texture, soil depth, and ground water use. The criteria have also been established so that there will not be a potential for adverse effects through contaminant transfer from soil to indoor air, from ground water or surface water through release of volatile gases, from leaching of contaminants in soil to ground water, or from ground water discharge to surface water. However, use of these criteria may not ensure that corrosive, explosive, or unstable soil conditions will be eliminated.

The Soil Remediation Criteria were developed from published U.S. EPA and Ontario environmental data bases. Currently there are criteria for about 25 inorganic elements and about 90 organic compounds. Criteria were developed only if there were sufficient, defendable, effects-based data on the potential to cause an adverse effect. All of the criteria address human health and aquatic toxicity, but terrestrial ecological toxicity information was not available for all elements or compounds. The development of Soil Remediation Criteria is a continuous program, and criteria for more elements and compounds will be developed as additional environmental data become available. Similarly, new information could result in future modifications to the existing criteria.

For more information on the Remediation Criteria please refer to the *Guideline for Use at Contaminated Sites in Ontario. Revised December 1996*, Ontario Ministry of Environment and Energy, PIBs 3161E01, ISBN 0-7778-5905-X.

Appendix 4: Derivation and Significance of the MOEE "Ontario Typical Range" Soil Guidelines.

The MOEE "Ontario Typical Range" (OTR) guidelines are being developed to assist in interpreting analytical data and evaluating source-related impacts on the terrestrial environment. The OTRs are used to determine if the level of a chemical parameter in soil, plants, moss bags, or snow is significantly greater than the normal background range. An exceedence of the OTR_{98} (*the OTR_{98} is the actual guideline number*) may indicate the presence of a potential point source of contamination.

The OTR represents the expected range of concentrations of chemical parameters in surface soil, plants, moss bags, and snow from areas in Ontario not subjected to the influence of known point sources of pollution. The OTR_{98} represents 97.5 percent of the data in the OTR distribution. This is equivalent to the mean plus two standard deviations, which is similar to the previous MOEE "Upper Limit of Normal" (ULN) guidelines. In other words, 98 out of every 100 background samples should be lower than the OTR_{98}.

The OTR_{98} may vary between land use categories even in the absence of a point source of pollution because of natural variation and the amount and type of human activity, both past and present. Therefore, OTRs are being developed for several land use categories. The three main land use categories are Rural, New Urban, and Old Urban. Urban is defined as an area that has municipal water and sewage services. Old Urban is any area that has been developed as an urban area for more than 40 years. Rural is all other areas. These major land use categories are further broken into three subcategories; Parkland (which includes greenbelts and woodlands), Residential, and Industrial (which includes heavy industry, commercial properties such as malls, and transportation rights-of-way). Rural also includes an Agricultural category.

The OTR guidelines apply only to samples collected using standard MOEE sampling, sample preparation, and analytical protocols. Because the background data were collected in Ontario, the OTRs represent Ontario environmental conditions.

The OTRs are not the only means by which results are interpreted. Data interpretation should involve reviewing results from control samples, examining all the survey data for evidence of a pattern of contamination relative to the suspected source, and where available, comparison with effects-based guidelines. The OTRs are particularly useful where there is uncertainty regarding local background concentrations and/or insufficient samples were collected to determine a contamination gradient. OTRs are also used to determine where in the anticipated range a result falls. This can identify a potential concern even when a result falls within the guideline. For example, if all of the results from a survey are close to the OTR_{98} this could indicate that the local environment has been contaminated above the *anticipated average,* and therefore the pollution source should be more closely monitored.

The OTRs identify a range of chemical parameters resulting from natural variation and normal human activity. ***As a result, it must be stressed that values falling within a specific OTR_{98} should not be considered as acceptable or desirable levels; nor does the OTR_{98} imply toxicity to plants, animals or humans.*** Rather, the OTR_{98} is a level which, if exceeded, prompts further investigation on a case by case basis to determine the significance, if any, of the above normal concentration. Incidental, isolated or spurious exceedences of an OTR_{98} do not necessarily indicate a need for regulatory or abatement activity. However, repeated and/or extensive exceedences of an OTR_{98} that appears to be related to a potential pollution source does indicate the need for a thorough evaluation of the regulatory or abatement program.

The OTR_{98} supersedes the Phytotoxicology ULN guideline. The OTR program is on-going. The number of OTRs will be continuously updated as sampling is completed for the various land use categories and sample types. For more information on these guidelines please refer to *Ontario Typical Range of Chemical Parameters in Soil, Vegetation, Moss Bags, and Snow. MOEE Report Number HCB-151-3512-93, PIBs Number 2792, ISBN 0-778-1979-1.*

Appendix 5 : Radionuclide values for soil samples collected in the village of Deloro and surrounding area

Station	Cs-137 Bq/g	K-40 Bq/g	Moisture %	Ra-226 Bq/g	Ra-228 Bq/g	Th-228 Bq/g	U-238 Bq/g
133	<0.01	0.96	22	0.02	<0.05	0.02	<0.10
134	<0.01	0.85	21	0.02	<0.05	0.02	<0.10
135	0.01	0.71	27	0.02	<0.05	<0.02	<0.10
136	0.01	0.71	25	0.01	<0.05	0.02	<0.10
137	0.01	0.85	22	0.02	<0.05	0.02	<0.10
138	0.02	0.83	28	0.02	<0.05	0.02	<0.10
139	0.01	0.8	20	<0.01	<0.05	0.02	<0.10
140	<0.01	0.84	24	0.01	<0.05	<0.02	<0.10
141	<0.01	0.66	19	0.02	<0.05	<0.02	<0.10
142	<0.01	0.91	21	0.01	<0.05	<0.02	<0.10
143	<0.01	0.52	18	<0.01	<0.05	0.02	<0.10
144	<0.01	0.87	25	0.01	<0.05	0.02	<0.10
145	<0.01	0.47	32	<0.01	<0.05	<0.02	<0.10
146	<0.01	0.78	23	0.01	<0.05	<0.02	<0.10
147	<0.01	0.66	23	<0.01	<0.05	<0.02	<0.10
148	<0.01	0.99	22	0.01	<0.05	0.02	<0.10
149	<0.01	0.59	19	0.02	<0.05	0.02	<0.10
150	<0.01	1.03	18	0.03	<0.05	<0.02	<0.10
151	<0.01	0.64	19	0.02	<0.05	0.02	<0.10
152	<0.01	0.83	25	0.02	<0.05	<0.02	<0.10
153	0.02	0.52	22	0.02	<0.05	<0.02	<0.10
155	<0.01	0.82	21	0.01	<0.05	<0.02	<0.10
156	<0.01	0.62	22	0.02	<0.05	0.02	<0.10
157	0.02	0.76	25	0.02	<0.05	<0.02	<0.10
158	<0.01	0.73	27	0.02	<0.05	<0.02	<0.10
159	0.03	0.63	26	0.03	<0.05	<0.02	<0.10
160	0.01	0.7	20	0.02	<0.05	0.02	<0.10
161	0.01	0.69	17	<0.01	<0.05	<0.02	<0.10
162	0.01	0.76	19	0.02	<0.05	<0.02	<0.10
163	<0.01	0.45	16	0.02	<0.05	<0.02	<0.10
164	<0.01	0.83	24	0.02	<0.05	<0.02	<0.10
165	<0.01	0.61	19	<0.01	<0.05	<0.02	<0.10
166	<0.01	0.75	24	0.02	<0.05	<0.02	<0.10
167	0.01	0.64	19	0.02	<0.05	<0.02	<0.10
168	<0.01	0.81	22	0.01	<0.05	0.02	<0.10
169	<0.01	0.53	23	<0.01	<0.05	<0.02	<0.10
170	0.01	0.74	24	0.02	<0.05	<0.02	<0.10
171	0.01	0.62	24	0.02	<0.05	<0.02	<0.10
172	<0.01	0.83	23	0.02	<0.05	<0.02	<0.10
173	<0.01	0.63	20	0.01	<0.05	0.02	<0.10
175	<0.01	0.65	26	0.01	<0.05	<0.02	<0.10
176	<0.01	0.59	25	0.01	<0.05	0.02	<0.10
177	0.01	0.74	23	0.02	<0.05	0.02	<0.10
178	<0.01	0.55	22	0.02	<0.05	<0.02	<0.10
179	<0.01	0.86	22	0.02	<0.05	<0.02	<0.10
180	0.01	0.61	25	<0.01	<0.05	0.02	<0.10
181	<0.01	0.62	21	<0.01	<0.05	<0.02	<0.10
182	<0.01	0.51	24	0.02	<0.05	0.02	<0.10
183	<0.01	0.5	17	0.02	<0.05	<0.02	<0.10
185	<0.01	0.58	26	0.02	<0.05	0.02	<0.10
186	<0.01	0.54	22	0.01	<0.05	<0.02	<0.10
187	<0.01	0.62	22	0.02	<0.05	0.02	<0.10
188	<0.01	0.57	22	0.02	<0.05	0.02	<0.10
189	0.01	0.52	24	<0.01	<0.05	0.02	<0.10

Station	Cs-137 Bq/g	K-40 Bq/g	Moisture %	Ra-226 Bq/g	Ra-228 Bq/g	Th-228 Bq/g	U-238 Bq/g
190	<0.01	0.46	25	0.02	<0.05	<0.02	<0.10
191	0.01	0.55	25	0.02	<0.05	0.02	<0.10
192	0.03	0.53	29	0.02	<0.05	<0.02	<0.10
193	0.01	0.64	24	0.01	<0.05	0.02	<0.10
194	<0.01	0.73	23	<0.01	<0.05	0.02	<0.10
195	0.01	0.57	24	<0.01	<0.05	<0.02	<0.10
196	0.02	0.65	25	0.02	<0.05	<0.02	<0.10
197	<0.01	0.66	17	0.03	<0.05	0.02	<0.10
198	<0.01	0.9	18	0.02	<0.05	0.02	<0.10
199	<0.01	0.67	20	0.02	<0.05	<0.02	<0.10
200	<0.01	0.85	17	0.02	<0.05	<0.02	<0.10
201	0.01	0.7	25	0.02	<0.05	0.02	<0.15
202	0.02	0.6	24	0.02	<0.05	0.02	<0.15
203	0.01	0.6	18	0.02	<0.05	0.02	<0.15
204	<0.01	0.7	22	0.02	<0.05	0.02	<0.15
205	0.01	0.6	22	0.02	<0.05	0.02	<0.15
206	0.01	0.6	23	0.02	<0.05	0.02	<0.15
207	0.01	0.6	26	0.02	<0.05	<0.02	<0.15
208	0.01	0.5	22	0.02	<0.05	0.02	<0.15
209	<0.01	0.8	20	0.02	<0.05	0.02	<0.15
210	<0.01	0.8	19	0.02	<0.05	0.02	<0.15
211	<0.01	0.6	18	0.02	<0.05	0.02	<0.15
212	0.01	0.8	19	0.02	<0.05	0.02	<0.15
213	<0.01	0.8	17	0.02	<0.05	0.02	<0.15
214	0.01	0.7	18	0.02	<0.05	0.02	<0.15
215	<0.01	0.8	19	0.02	<0.05	0.02	<0.15
217	0.01	0.8	21	0.02	<0.05	0.02	<0.15
218	<0.01	0.6	21	0.02	<0.05	<0.02	<0.15
219	0.01	0.7	21	0.02	<0.05	0.02	<0.15
220	<0.01	0.6	22	<0.01	<0.05	<0.02	<0.15
221	<0.01	0.7	21	0.02	<0.05	0.02	<0.15
222	<0.01	0.9	18	0.02	<0.05	0.02	<0.15
223	0.02	0.7	18	0.02	<0.05	0.02	<0.15
224	<0.01	0.8	18	0.02	<0.05	0.02	<0.15
225	<0.01	0.6	21	0.02	<0.05	<0.02	<0.15
227	0.01	1	24	0.02	<0.05	0.02	<0.15
228	0.01	0.9	22	0.02	<0.05	0.02	<0.15
229	0.02	0.7	22	0.02	<0.05	0.02	<0.15
230	<0.01	0.8	20	0.02	<0.05	0.02	<0.15
232	0.01	0.7	25	0.02	<0.05	0.02	<0.15
232	<0.01	0.8	21	0.02	<0.05	0.02	<0.15
233	<0.01	0.8	16	0.02	<0.05	<0.02	<0.15
234	0.01	0.8	20	0.02	<0.05	0.02	<0.15
235	0.01	0.7	24	0.02	<0.05	<0.02	<0.15
236	<0.01	0.8	22	0.02	<0.05	0.02	<0.15
237	0.01	0.7	24	0.02	<0.05	0.02	<0.15
238	0.01	0.8	23	0.02	<0.05	0.02	<0.15
239	<0.01	0.6	20	0.02	<0.05	<0.02	<0.15
241	<0.01	0.7	18	0.02	<0.05	<0.02	<0.15
242	<0.01	0.9	18	0.03	<0.05	0.02	<0.15
243	<0.01	0.7	19	0.02	<0.05	0.02	<0.15
244	0.01	0.7	20	0.02	<0.05	0.02	<0.15
245	0.01	0.6	24	0.02	<0.05	0.02	<0.15
247	0.01	0.6	24	0.02	<0.05	0.02	<0.15
248	0.01	0.8	24	0.02	<0.05	0.02	<0.15
249	0.02	0.7	24	0.02	<0.05	0.02	<0.15

Station	Cs-137 Bq/g	K-40 Bq/g	Moisture %	Ra-226 Bq/g	Ra-228 Bq/g	Th-228 Bq/g	U-238 Bq/g
250	0.01	0.9	25	0.02	<0.05	0.02	<0.15
251	0.01	0.7	26	0.02	<0.05	0.02	<0.15
252	<0.01	0.8	20	0.02	<0.05	<0.02	<0.15
253	<0.01	0.7	21	0.02	<0.05	0.02	<0.15
255	<0.01	0.6	19	<0.01	<0.05	<0.02	<0.15
256	<0.01	0.7	18	0.02	<0.05	0.02	<0.15
257	<0.01	0.8	17	0.02	<0.05	<0.02	<0.15
258	<0.01	0.6	25	0.02	<0.05	<0.02	<0.15
259	<0.01	0.7	17	0.01	<0.05	0.02	<0.15
260	<0.01	0.7	15	0.01	<0.05	<0.02	<0.15
261	<0.01	0.8	17	0.02	<0.05	<0.02	<0.15
262	0.01	0.6	22	0.02	<0.05	0.02	<0.15
263	<0.01	0.7	23	0.01	<0.05	0.02	<0.15
264	0.01	0.6	28	0.02	<0.05	<0.02	<0.15
265	0.02	0.7	26	0.02	<0.05	<0.02	<0.15
254	<0.01	0.8	19	0.02	<0.05	0.02	<0.15
246	0.01	0.9	20	0.02	<0.05	0.02	<0.15
154	<0.01	0.7	18	0.02	<0.05	0.02	<0.15
240	<0.01	0.6	21	0.02	<0.05	0.02	<0.15
226	<0.01	0.8	20	0.02	<0.05	0.02	<0.15
174	<0.01	0.8	31	0.01	<0.05	<0.02	<0.15
184	<0.01	0.7	22	0.02	<0.05	0.02	<0.15
216	<0.01	0.7	19	0.01	<0.05	<0.02	<0.15
266	<0.01	0.6	16	0.02	<0.05	0.02	<0.15
267	<0.01	1.2	19	0.03	<0.05	0.02	<0.15
mean		0.71	22	0.02			
median		0.7	22	0.02			
minimum		0.45	15	<0.01			
maximum		1.2	32	0.03			
Background*	NA	NA	NA	0.025	NA	NA	NA

* mean background value for Ra-226 in Ontario soils (Clement, 1997)
NA - not available